DOCUMENT RESUME

ED 105 406 CS 001 731

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TITLE An Aspect of Critical Thinking: Predicting Students' Use of Evidence.
PUB DATE 1 Apr 75
NOTE 12p.; Paper presented at the Annual Meeting of the American Educational Research Association (Washington, D.C., March 30-April 3, 1975)

EDRS PRICE MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS *Critical Reading; *Critical Thinking; Multiple Regression Analysis; *Predictive Ability (Testing); Reading Ability; *Reading Research; *Reading Skills; Secondary Education; Student Characteristics; Task Performance; Verbal Ability

ABSTRACT

This study seeks to illuminate those characteristics of students which predict their performance in using evidence to test a hypothesis. The research is conceived as part of a larger investigative strategy for understanding the relationships among characteristics of students, characteristics of social studies thinking tasks, and characteristics of instructional variables. Stepwise multiple regression using five variables--verbal ability, age, socioeconomic status, educational expectation, and sex--is employed to predict students' use of evidence. Subjects are 304 students in grades seven, nine, and eleven. Results reconfirm the importance of verbal ability as a predictor in verbally loaded tasks (predicting 25 percent of variance), but surprisingly neither age nor socioeconomic status are found as significant predictors. Implications are drawn for curriculum decision making. Suggestions for further research are enumerated. (Author)

ED105406

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AN ASPECT OF CRITICAL THINKING: PREDICTING STUDENTS' USE OF EVIDENCE

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ABSTRACT

This study seeks to illuminate characteristics of students which enable us to predict their performance in using evidence to test a hypothesis. The research is conceived as part of a larger investigative strategy for understanding the relationships among characteristics of students, characteristics of social studies thinking tasks and characteristics of instructional variables. Stepwise multiple regression using the variables, Verbal Ability, Age, Socio-Economic Status, Educational Expectation and Sex is employed to predict students' Use of Evidence. Subjects are three hundred and four students in grades seven, nine and eleven. Results reconfirm the importance of verbal ability as a predictor in verbally loaded tasks (predicting 25% of variance), but surprisingly neither Age nor Socio-Economic Status are found as significant predictors. Implications are drawn for curriculum decision making. Suggestions for further research are enumerated.

A Paper presented to the Annual Meeting of the American Educational Research Association, April 1, 1975

CS 001 731

AN ASPECT OF CRITICAL THINKING:

Predicting Students' Use of Evidence

OBJECTIVES

Trends and fads have come and gone, but for at least the past thirty years there has been a recurrent theme in the social studies literature that students must be taught to be independent, critical thinkers. Whether we have used the term "problem solving," "reflective thinking," "critical thinking," "inductive approach," "discovery," or "inquiry," we have meant--at least in part--that students should learn to think on their own.

This study seeks to illuminate the characteristics of students which enable us to predict their ability to make use of evidence in testing statements. The study extends research reported last year on the performance of 9th grade students on some critical thinking tasks. That research identified verbal ability as the single most robust variable in the prediction of student performance. This study extends the earlier research by introducing several other variables which might be expected to contribute to a further understanding of students' critical thinking. These variables are age, socio-economic status, educational expectation and sex.

THEORETICAL FRAMEWORK

As the term is used here, critical thinking is defined as the evaluation of evidence or argument in the light of acceptable standards for the purpose of deciding whether to accept or reject a statement. This definition is derived from the works of Smith and Ennis. (Smith, 1953), (Ennis, 1967). Building from Ennis' analysis, critical thinking is operationalized as a set of tasks which call upon students to engage in critical thinking operations. Just as arithmetic deals with tasks which require the operations of combination, division, etc., critical thinking in the social studies can be conceived as a group of tasks which require operations such as judging the relevance of evidence, judging the reliability of evidence, judging whether a statement follows from premises, identifying unstated assumptions, etc.

The research is based upon the hunch that (1) characteristics of students and (2) characteristics of tasks with which students are expected to interact should prove to be a fruitful line of investigation. This study is part of a larger research strategy which is seeking to establish a baseline of information about the relationships among students' characteristics and social studies thinking tasks. The baseline of information should, then, enable a systematic investigation of instructional variables and their impact upon student performance. In the meantime, it is expected that results of the present study plus related studies should provide useful knowledge for helping us understand our students' performance in critical thinking.

The major question being asked in this study is whether there are identifiable aptitudes and characteristics of students which enable us to better understand their use of evidence in testing statements, or hypotheses. More specifically, this study

examines five characteristics of students as predictors of performance in using evidence: students' Verbal Ability, Age, Socio-Economic Status (SES), Educational Expectation and Sex. For each of these characteristics, this study asks the question, "Does this characteristic of students enable us to predict performance in using evidence?"

METHOD

Data Analysis

Stepwise multivariate regression analysis was performed on the data using the Statistical Package for the Social Sciences (SPSS) programs. Stepwise regression enables the entry of predictor variables into the analysis in a manner such that each predictor variable operates as a covariant, or control variable, for each successive predictor variable.

Statistical Significance

Two criteria were employed to establish significant results. Statistical significance was set at .05. More importantly, no predictor sharing less than 5% of the total variance with the criterion variable was considered a significant result.

Variables

Criterion Variable--

Students' use of evidence in testing a statement was the criterion, or dependent variable. This was measured by administering Section I, Part A of "The Cornell Critical Thinking Test, Level X." This part of the test is comprised of twenty-three items plus two practice items. Reliability of the instrument for all classes using the KR_{20} procedure of inter-item reliability was .754. The test was administered by teachers in their social studies classes. This section and part of the Cornell Level X Test measures students' performance in distinguishing evidence which is supportive, negative or irrelevant to a statement.

Predictor Variables--

Five variables were used to predict student use of evidence: verbal ability, sex, age, educational expectation and socio-economic status.

Verbal ability was measured using the "Wide Range Vocabulary Test" with the format altered to permit machine scoring. This instrument proved highly reliable.

Age was measured by self-reports of students and calculated in months. Students came from the 9th and 11th grade classes. Although age is not itself an explanatory construct it is associated with general mental maturity and in the case of several developmental theories, notably that of Piaget, it is a consistent correlate of certain logical operations. Peel identifies mid-adolescence as a time when students demonstrate an ability to make co-ordinated judgments in the fields of history and geography.

Both sex and SES, were measured by self-reports. SES was indicated by a single measure of students of their father's occupation. This self-report was then coded by a single coder employing a scale developed by N.O.R.C. Of all the measures, SES is the least satisfactory.

Educational expectation was generated by asking students to indicate the highest schooling they expect to complete. This is a measure which might well be expected to correlate highly with SES and verbal ability but which is included as a rough measure of students' perception of the place of schooling in their future.

SUBJECTS

Three-hundred-four students from two schools took part in this research. The schools were from a single school district in a growing small city of about 150,000 population in the Middle Atlantic States region. The research made use of whole-class groups which were chosen to provide a wide range of academic ability. There were 113 7th grade pupils, 94 9th grade pupils and 97 11th grade pupils. The pupils were overwhelmingly white with blacks comprising no more than 10 percent of the sample.

R E S U L T S

Before examining results of the stepwise regression analysis, we will take a look at some descriptive data which should help us "get a feel" for the data. Table I displays the correlation matrix among the predictor and criterion variables.

Table One about Here

The results which are of most interest are found in the column farthest to the right in which each of the predictor variables is correlated with the criterion variable. With the exception of Sex, all of the predictors are correlated positively and significantly with Use of Evidence.

That is, with the exception of Sex, all of the variables vary in approximately the same manner as Use of Evidence. For example, the correlation of .39 between Age and Use of Evidence indicates that as Age goes up performance on Use of Evidence tends to go up, etc.

It must also be noted that the predictors correlated with one another. For instance, the largest coefficient of correlation is between Age and Verbal Ability. There is also a statistically significant relationship among Verbal Ability and Socio-Economic Status. Thus, the important question which remains is how the mix of variables contributes to prediction of students' use of evidence. To examine this, stepwise multiple regression is used.

Results are summarized on Table 2. Verbal Ability was entered as the first

predictor. Thus, it served as a covariant for all later variables. Other variables were selected automatically by the program in the order of their magnitude of prediction. The table below provides five values for each variable. "B" and "Beta" values are the regular and normalized regression coefficients, respectively. The third value is the standard error of B. Where this value is considerably less than B, then the sign of the regression coefficient can be considered significant. "F" is an indicator of statistical significance. In this case, any F value falling between 2.25 and 3.10 has a 5% probability of chance. Any F value falling at 3.11 or above has a 1% probability of chance. The last column on the table indicates the percentage of variance predicted by the variable. As indicated in the earlier discussion of "Statistical Significance," this last value on the table is of interest since it is quite possible for a variable to be statistically significant, but for it to predict so little variance in the criterion variable that it is of no practical importance.

Table Two About Here

Verbal Ability, the first predictor to enter the analysis shows both a high statistical significance with a chance probability of less than .001 and a highly significant prediction of variance with 26 percent. That is, students' Verbal Ability predicts about one-fourth of their performance on the Use of Evidence measure. The F ratio for Sex indicates that the findings are statistically significant (less than .01 chance results); however, it predicts only 1.2 percent of the variance on the Use of Evidence. The negative signs in front of the "B" and "Beta" columns indicate that females performed better than males. As with Sex, Age is statistically significant (less than .01 chance results), but contributes only 1.9 percent of variance. Finally, only Socio-Economic does <u>not</u> contribute a statistically significant prediction.

Several results are notable. Verbal Ability contributes a sizable percentage of variance in the prediction. This result is certainly expected and is consistent with both theory and previous results. What is most surprising is the negligible contributions of Age and SES to the prediction. Age has more than a modest correlation (.39) with the criterion variable, but that relationship relies almost totally upon Verbal Ability. The weak predictive power of SES is not so easy to explain. Its low correlation with the criterion variable (.15) leads to several possible explanations.

The first potential explanation would be that subjects in the study were relatively homogeneous with regard to SES and, therefore, this variable had little correlational or predictive power. The Socio-Economic Index scale used in this study has a range of values from 0 to 96. Seventh graders, ninth graders and eleventh graders in this study had a range of values of 86, 92 and 82 respectively. The standard deviations of values were 22, 23 and 23 respectively. Thus, this first potential explanation is not supported by the data.

The second potential explanation is that the values are not reliable. There are at least two potential sources of unreliability. The first flows from the fact that a single measure was employed. That is, students were asked to report

their father's occupation. The second flows from the fact that a single rater translated reports of occupation into SES values. To check this source of unreliability a second rater, operating independently rated occupations and inter-rater reliability of .90 was calculated.

Of the remaining variables, both Sex (favoring females) and Educational Expectation proved statistically significant; however, neither contributed a sufficient percentage of variance to be considered a significant predictor.

Thus of the five predictors of students' Use of Evidence, only Verbal Ability contributed significantly to prediction. Interactions among each pair of predictors and the criterion were tested and found to add nothing to the prediction.

IMPLICATIONS AND FURTHER RESEARCH

The most surprising result of this study was the paltry relationship between the SES indicator and the measure of students' use of evidence. Given the consistent findings of strong relationships between SES and school achievement, (most notably in the "Coleman Report") I expected SES to add significantly to the prediction of students' performance in the use of evidence. Whether the result is a solid finding or simply the result of error in measurement or some unknown peculiarity of the sample awaits further study.

In terms of curriculum decision making, the most significant findings are the relatively high predictive power of Verbal Ability (predicting 26% of variance) and the almost non-existent predictive power of Age (about 2%) when Verbal Ability is the covariant. (Age predicts about 12.8% of variance when Verbal Ability is not used as a covariant.) These findings downplay the importance of age--and its correlate, maturation--as an important variable in explaining students' Use of Evidence. More specifically, these findings indicate that Verbal Ability is a more important predictor than Age of how well students will be able to interact with a curriculum that calls upon Use of Evidence.

It is important to note that this research does <u>not</u> purport to identify any fixed and immutable level of Verbal Ability below which students are incapable of using evidence. Indeed, it may be possible to identify instructional or curriculum practices which can help students overcome weaknesses in ability to use evidence. However, the research findings indicate that if a social studies department is interested in matching an evidentially based curriculum with students who can perform well in that curriculum, it is better to use Verbal Ability than Age as a criterion.

The limitations within which it is reasonable to interpret results of this study point toward further potentially profitable studies. First, it should be noted that this study operationalized the construct "Use of Evidence" in a very specific way. The task given the students was verbal and given in a written format. It dealt with what is for most people a relatively familiar set of meanings. That is, it dealt with the concept of death and the implications of death--e.g., that one is not around to disturb things, etc.--In short, all of these characteristics of the task might be expected to influence students' performance. Further studies might wish to operationalize the task in a different manner. In particular, it would be informative to develop several additional instruments which follow the format of the Cornell instrument but which deal with conceptual matter of differing levels of difficulty.

Second, it must be noted that this research examined 12 to 16 year olds and that results need to be interpreted in this light. Further research might examine performance of younger students in using evidence. The difficulty is, of course, in developing instruments which are sensitive to the subjects. It might be useful to develop visual displays of evidence and oral interview instruments.

Third, further studies should examine predictors of student performance on other critical thinking tasks. (The author is currently examining student ability to distinguish between causative and correlative explanations.) Fourth, it should be noted that the five predictors employed in this research were able to account for only about 31 percent of the shared variance among the predictors and the criterion variable. It would be very useful to know if there are any further predictors which enable us to enhance prediction. Increasing the reliability of instruments should increase the percentage of variance accounted for.

Fifth, a more rigorous examination of the predictive ability of SES needs to be undertaken. Multiple measures of SES should be included. Sixth, it should be profitable to examine students' performance on critical thinking tasks in the light of Piaget's work. If Piaget is correct in his identification of logical development through stages which are largely independent of Verbal Ability, it should be possible to identify at least some critical thinking tasks in which Piagetian indicators predict a significant amount of variance beyond that predicted by Verbal Ability. Finally, it should be remembered that replication is the best test of the reliability of research findings.

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TABLE 1

Correlation Matrix Among All Variables

	Age	V.A.	SES	Ed.Ex.	Sex	Use of Evidence
Age	1.00	.54**	.03	-.11*	.02	.39**
Verbal Ability		1.00	.23**	.17**	.11*	.51**
SES			1.00	.17**	.04	.15**
Educational Expectation				1.00	-.05	.19**
Sex					1.00	-.07
Use of Evidence						1.00

$p < .05$*

$p < .01$**

TABLE 2

Multiple Regression Analysis: Predicting Students' Use of Evidence

Variable	B	Beta	Std.Error of B	F	% of Variance Predicted
Verbal Ability	.087	.396	0.016	31.01***	26.0
Sex	-.819	-.111	0.423	3.75**	1.2
Age	.035	.189	0.013	7.31**	1.7
Educational Expectation	.260	.134	0.116	5.01**	1.9
Socio-Economic Status	-0.015	-0.043	0.020	Insig.	Unreliable

$P < .05$*

$P < .01$**

$P < .001$***

Interactions among all of the predictor variables were tested and found insignificant.

APPENDIX A

Part I, Section A, What Happened to the First Group

The first job of your group is to find out what happened to the first group of 15 explorers. Your group has landed on Nicoma and has just discovered the metal huts put up by the first group. The huts appear to be in good condition from the outside. It is a warm day and the sun is shining. The trees, rocks, grass, and birds make this part of Nicoma appear about like parts of central United States.

You and the health officer are the first to arrive at the group of huts. You call out, but get no answer.

The health officer suggests, "Maybe they're all dead." You investigate.

Below are listed a number of facts which you learn. For each fact you must decide if it would be evidence for, or evidence against, the health officer's idea that they are all dead. However, the fact might not be neither evidence for, nor evidence against the health officer's idea.

For each fact, mark one of the following on your answer sheet:

A. This fact is evidence in support of the health officer's idea that they are all dead.

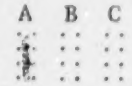
B. This fact is evidence against the health officer's idea that they are all dead.

C. Neither. Discovery of this fact makes no difference.

Here is a sample:

1. You go into the first hut. Everything is covered by a thick layer of dust.

This fact is evidence in support of the health officer's idea. It certainly is not enough to prove his idea, but is evidence for it. Using the special pencil, blacken the space under A for No. 1 on your answer sheet--like this:



Here is another example:

2. Other members of your group discover the first group's rocket ship nearby.

What do you say about that fact? Mark your answer by No. 2 on your answer sheet. Do it now.

You should have marked C. This fact about the rocket ship does not help us decide whether the members of the first group are dead. If you did not mark C, erase your mark thoroughly and mark C.

Here is a list of facts. For each one mark A, B, or C. If you have no idea which to mark, leave that one blank and go on to the next one. Consider the bearing of each fact at the time that it becomes known. Do so in the order in which they are numbered. Work slowly and carefully, and do not return to an item once you have left it. Reminder--mark as follows:

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